

(12) **United States Patent**
Border et al.

(10) **Patent No.:** **US 8,593,564 B2**
(45) **Date of Patent:** **Nov. 26, 2013**

(54) **DIGITAL CAMERA INCLUDING
REFOCUSABLE IMAGING MODE ADAPTOR**

(75) Inventors: **John Norvold Border**, Walworth, NY
(US); **Richard D. Young**, Fairport, NY
(US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/239,472**

(22) Filed: **Sep. 22, 2011**

(65) **Prior Publication Data**

US 2013/0076930 A1 Mar. 28, 2013

(51) **Int. Cl.**
H04N 5/225 (2006.01)

(52) **U.S. Cl.**
USPC **348/360**; 348/340

(58) **Field of Classification Search**
USPC 348/360, 345, 207.99, 340, 361
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,971,065	A	7/1976	Bayer
4,642,678	A	2/1987	Cok
4,774,574	A	9/1988	Daley et al.
5,189,511	A	2/1993	Parulski et al.
5,282,045	A	1/1994	Mimura
5,493,335	A	2/1996	Parulski et al.
5,652,621	A	7/1997	Adams, Jr. et al.
5,668,597	A	9/1997	Parulski et al.
5,883,695	A	3/1999	Paul
6,192,162	B1	2/2001	Hamilton, Jr. et al.
6,292,218	B1	9/2001	Parulski et al.
6,934,056	B2	8/2005	Gindele et al.
7,542,077	B2	6/2009	Miki

7,723,662	B2 *	5/2010	Levoy et al.	250/208.1
7,847,837	B2	12/2010	Ootsuna	
7,936,392	B2	5/2011	Ng et al.	
7,965,936	B2 *	6/2011	Raskar et al.	396/268
2007/0024931	A1	2/2007	Compton et al.	
2007/0252074	A1 *	11/2007	Ng et al.	250/208.1
2008/0309813	A1 *	12/2008	Watanabe	348/340
2010/0026852	A1	2/2010	Ng et al.	
2010/0128145	A1	5/2010	Pitts	

FOREIGN PATENT DOCUMENTS

JP 2006078713 3/2006

OTHER PUBLICATIONS

Ng et al., "Light field photography with a hand-held plenoptic camera," Stanford Tech Report CTSR Feb. 2005.
Search Report and Written Opinion received in corresponding PCT Application No. PCT/US2012/055410, dated Mar. 28, 2013.

* cited by examiner

Primary Examiner — James M Hannett

Assistant Examiner — Ahmed A Berhan

(74) *Attorney, Agent, or Firm* — Wong, Cabello, Lutsch,
Rutherford & Brucculeri, LLP

(57) **ABSTRACT**

A digital camera system configurable to operate in a low-resolution refocusable mode and a high-resolution non-refocusable mode comprising: a camera body; an image sensor mounted in the camera body having a plurality of sensor pixels for capturing a digital image; an imaging lens for forming an image of a scene onto an image plane, the imaging lens having an aperture; and an adaptor that can be inserted between the imaging lens and the image sensor to provide the low-resolution refocusable mode and can be removed to provide the high-resolution non-refocusable mode, the adaptor including a microlens array with a plurality of microlenses; wherein when the adaptor is inserted to provide the low-resolution refocusable mode, the microlens array is positioned between the imaging lens and the image sensor.

15 Claims, 10 Drawing Sheets

